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Subject Design Calculations for the Waste System Evaporator Reboiler WL-300, Waste Evaporator Condenser WL-301, and Ejector Exhaust Condenser WL-302

By A. F. Arruzza

To F. L. Culler

Distribution:

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DECLASSIF... ... Instructions Of TID 1133

For: N. T. B...
Laboratory Records Dept.
ORNL

This document has been approved for release to the public by:

David R Hamrin 5/19/95
Technical Information Officer Date
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Introduction

As a result of the chemical processing of radioactive materials, liquid wastes ensue which are also radioactive. These wastes must be processed in order to reduce the volume sufficiently for adequate storage. This is achieved by evaporating the water from the waste and discharging the water to the service waste system. The concentrated radioactive waste is sent to storage for an indefinite period.

This report deals with the specifications for the major items of equipment in the waste system and the calculations for the evaporator and condensers. Calculations for items of equipment such as the column, tanks, etc., do not appear in this report because they were extended by the Knoll Atomic Power Laboratory at Schenectady, N. Y. The Knoll Laboratory successfully processes a liquid waste comparable in content and volume to that of the Idaho CPP. Their design, sizes, etc. of vessels and system was used in order to save time, effort and expenditure.

Basis for Design

The design of the waste system was based on flows contained in secret documents ORNL 50-6-121, 50-8-146, and 50-10-167. Blaw-Knox Tube Standards were used in the calculations of the evaporator and condensers. However, Foster Wheeler Company changed the calculated results to comply with the Foster Wheeler Tube Standards. (Foster Wheeler fabricated these vessels)

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Preliminary Specification of Waste Evaporator

1.0 Purpose

The purpose of the waste evaporator is to concentrate the radiochemical waste from the chemical Separations Process by evaporating water from the waste. The condensate water will be monitored for radioactivity and either discharged to the service waste system or re-evaporated until the radioactivity is low enough to permit discharge to the service waste system. The limit of radioactivity permitted in this water has not yet been established but will be low (in the order of 10 β counts per minute per milliliter). The concentrate from the evaporator will be stored indefinitely in an underground stainless steel tank.

2.0 Duty

The waste evaporator will receive an estimated 20,000 gallons of radiochemical waste per week from the two 5,000 gallon radiochemical waste collection tanks, WG-101 and WH-100, in the CPP Building plus an occasional undetermined quantity of floor drain waste from collection tanks WG-100 and WH-101 in the CPP Building. The radiochemical waste will be a dilute aqueous solution containing small quantities of $Al(NO_3)_3$, $NaNO_3$, Na_3PO_4, sodium citrate and other salts. It is estimated that the maximum total solids content of radiochemical waste will be 2.0%. The viscosity, specific gravity, specific heat, and other characteristics affecting evaporation shall be considered those of water. The fission products, which cause the radioactivity, will be present in too low chemical concentrations to affect evaporation chemically. The amount of radioactivity in the raw radiochemical waste is estimated to average 10^6 β counts per minute per milliliter.

The waste evaporator shall evaporate 300 gallons of water per hour continuously from the waste fed to it. The evaporator shall be capable of operating at atmospheric pressure or at 100 millimeters Hg absolute pressure. A decontamination factor of 10^5 is expected, so that the radioactivity in the evaporated water should be in the order of 10 β counts per minute per milliliter. The waste shall be concentrated by a factor of 30 to 1 or to a specific gravity of 1.3, the 1.3 specific gravity to be the determining factor. No concentrate shall be discharged until the specific gravity reaches 1.3. The combined volume of the reboiler (WL-300) and flash column (WL-113) shall be great enough to accommodate the accumulated concentrate from a minimum of five days continuous operation. The characteristics of the recirculating thermosyphon reboiler (WL-300) shall be such as to permit the continuous accumulation and recirculation of concentrate at the rate of 10 gallons per hour for a minimum of five days.

Cold water (55° C) shall be admitted to the top bubble-cap tray of the separator column (WL-112) at a maximum rate of 30 gallons per hour for the purpose of reflux. This reflux must be evaporated, so that the total vapor load will be 300 gallons (2500 lbs.) per hour plus 30 gallons (250 lbs.) per hour or a total of 330 gallons (2750 lbs.) per hour. The feed rate will be about 310

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gallons (2580 lbs.) per hour.

3.0 Equipment

The engineering flowsheets (Dwgs. 542-21-P359 and 542-21-P360) show the schematic arrangement of the waste evaporator equipment as well as the size of each vessel and the nozzles required. The layout sketches show the proposed actual arrangement of the equipment in the cell and cold tank room of the Waste Evaporator and Off-Gas Building.

3.1 Waste Evaporator Surge Tanks (WL-101 & 102)

Drawing 542-12-V500 shows the details of the two 17,600 gallon underground, stainless steel surge tanks WL-101 & 102, which will receive all waste fed to the evaporator. ORNL drawing D-6233 shows the details of a float-type liquid level indicator and a sampler used for underground waste tanks at Oak Ridge. Sketch 542-SKCR V-116 shows an arrangement for boosting the sampler jet suction lift to permit the jet to lift over 25 feet. ORNL Drawing CL-706D-150 shows the details of the sampler jet used at Oak Ridge. This jet will work on steam or air as the driving fluid. Schutte & Koerting Co. Drawing G17467J shows the dimensions of S & K Fig. 233 steam jet syphons. Schutte & Koerting Co. has recommended their size 3/4" Fig. 233 jet to be submerged in tanks WL-101 & 102 for transferring 10 gallons of waste per minute to feed tank WL-109 in the evaporator cell. Drawings or detailed specifications on the liquid level recorder-alarm for WL-101 & 102 will be prepared later at ORNL. Details of the diversion boxes on the lines from WG-101

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& WH-100 to WL-101 & 102 will be prepared later at ORNL.

3.2 Waste Evaporator Feed Tank (WL-109)

An equipment specification sheet (vessel sketch) and a photostat of a sketch of WL-109 have been prepared. This small tank (300 gallons capacity) is to serve as a gravity feed tank for the evaporator. A liquid level recorder-controller shall actuate the submerged jets in tanks WL-101 & 102 to fill WL-109 each time it nearly empties. An overflow line from WL-109 to WL-102 shall be provided, but the level controller shall shut off the feed jet each time WL-109 fills in order to minimize dilution of the waste by the steam supplied to the jet. A temperature recorder shall be provided for this feed tank.

3.3 Waste Evaporator Flash Tank (WL-113)

An equipment specification sheet (vessel sketch) and a photostat of Blaw-Knox Drawing 2828-113-1 of the Knoll evaporator flash tank, from which WL-113 is modeled, have been prepared. The main purpose of the flash tank is to provide capacity for concentrate build-up in order to allow the evaporator to run for at least five days without shutting down to drain out concentrate. This means that the feed inlet from WL-109 and the vapor inlet from the thermosyphon reboiler (WL-300) must be at least five feed above the lower tank line of WL-113 to provide 1200 gallons build-up capacity.

A level recorder-controller shall be provided to regulate the feed rate from WL-109 to WL-113. This device shall maintain a minimum liquid level in WL-113, which is sufficient to keep the reboiler tubes completely submerged. Because most of the volume of WL-113 will be occupied by liquid while the evaporator is operating, most of the internal baffeling of the Knoll flash tank can be eliminated. Some internal spray nozzles to aid in decontaminating the vessel and a raw steam sparger to preheat the liquid shall be provided. A density recorder-alarm shall be provided to warn of the build up of concentrate. The temperature in both the vapor and liquid portions of WL-113 shall be recorded. A sampler shall be provided also.

The control system shown on the evaporator flowsheet (Drawing 542-21-P359) proposes the following:

1. Manual setting of a steam pressure indicator-controller to regulate steam flow to the reboiler (WL-300)
2. Liquid level in flash tank (WL-113) to control feed rate and submergence of reboiler tubes
3. Feed rate to be determined by an integrating flow rate indicator on WL-109 or by the build-up of condensate in the condensate receivers (WL-106 & 107).

An alternate control system would be the following:

1. Feed rate to WL-113 to control steam flow to the reboiler
2. Liquid level in WL-113 to reset the steam rate to protect reboiler tube submergence.

This system hinges on the availability of a satisfactory feed flow rate indicator-controller. Such a device must be so constructed as to avoid mechanical connection between the actuating device in the feed stream and the outside. Packing glands of mechanisms exposed to radioactive fluids are sources of serious difficulties and their use must be avoided. An electro-magnetic type flowmeter, which uses the flowing liquid as the actuating medium, is in the development stage at ORNL and shows promise for adaptation to this waste evaporator. Foster Wheeler should investigate the availability of commercial flow indicator-controllers having the characteristics desired for this installation.

3.4 Waste Evaporator Reboiler (WL-300)

An equipment specification sheet (vessel sketch) and a photostat of a sketch of WL-300 have been prepared. The reboiler has been sized according to ORNL calculations based on the required duty. Foster Wheeler should check this sizing and should calculate the recirculation rate for atmospheric and vacuum evaporation to determine if the proposed arrangement for the vertical themosyphon is satisfactory. The difficulty of steam condensate removal when evaporating at 90 mm. Hg absolute pressure and maintaining a mean temperature differential of 60° F should be investigated by Foster Wheeler. This difficulty might be overcome by controlling the flow of condensate instead of controlling the steam flow to the reboiler.

3.5 Waste Evaporator Separator Column (WL-112)

An equipment specification sheet (vessel sketch), a photostat of Blaw-Knox Drawing 2828-112-1 of the Knoll evaporator separator column, from which WL-112 is modeled, and a photostat of an ORNL sketch of WL-112 have been prepared. On the ORNL sketch the number of manholes and nozzles on WL-112 has been reduced from that shown on the Knoll separator column. Internal manways shall be provided in the top two bubble cap trays of WL-112. Internal baffles have been added to the lower section of WL-112 to aid the removal of entrainment. Steam and air shall be supplied to a sparger in the bottom of WL-112 for use during decontamination of the vessel. Cold water passing through a rotameter and a control valve shall be introduced into the top bubble cap tray to serve as reflux. A pump or a steam jet syphon shall drain the column at the bottom, discharging the liquid into the flash tank (WL-113) above the liquid level in WL-113. The suction line and jet will have to be jacketed for water cooling if a jet is used. A jet is preferable to a pump because of the maintenance consideration. Temperature and pressure measurements shall be taken at several points in the column as indicated on the flowsheet (Drawing 542-21-P359) and a differential pressure indicator shall show the pressure drop across the column.

3.6 <u>Waste Evaporator Condenser (WL-301)</u>

An equipment specification sheet (vessel sketch) and a photostat of an ORNL sketch of WL-301 have been prepared. This condenser has been sized according to ORNL calculations based on the required duty. Foster Wheeler should check this sizing and should calculate the baffling requirement on the shell side to determine if the proposed arrangement is satisfactory for both vacuum and atmospheric evaporation.

3.7 Waste Evaporator Receiving Tanks (WL-106 & 107)

An equipment specification sheet (vessel sketch) and a photostat of Blaw-Knox Drawing 2828-A518-1 of the Knoll evaporator receiving tanks, from which WL-106 & 107 are modeled, have been prepared. In operation one tank at a time will collect condensate, the selection of the tank being made by means of valves accessible to operators. Each tank shall have a sampler, level recorder-alarm, temperature recorder, and pressure indicator. Each tank shall be capable of venting to the tank room atmosphere for relieving the vacuum before emptying, venting to the steam jet exhauster for vacuum operation, or venting to the off-gas system for atmospheric operation. The condensate shall be drained from the tanks after a sample has been analyzed to determine the radioactivity. A pump (WL-206) shall discharge the condensate either to a service waste drain or to WL-102 for re-evaporation according to the radioactivity.

3.8 Waste Evaporator Steam Jet Exhauster

The steam jet exhauster for producing the vacuum for the waste evaporator shall be a type which produces no flash-back under shut-off conditions. An Elliot or an Ingersoll-Rand is preferred. The capacity shall be determined by Foster Wheeler. A means of regulating the vacuum in the evaporator shall be established by Foster Wheeler also.

3.9 Waste Evaporator Ejector Exhaust Condenser (WL-302)

An equipment specification sheet (vessel sketch) and a photostat of Patterson-Kelley Drawing C-1748-3 of the Knoll evaporator ejector exhaust condenser, which is identical with WL-302, have been prepared. On the Knoll evaporator this condenser condenses 462 pounds of steam per hour and subcools the condensate 128° F, and this has been taken as the duty for WL-302.

3.10 Waste Evaporator Separator (WL-108)

An equipment specification sheet (vessel sketch) and a photostat of Blaw-Knox Drawing 2828-A529-1 of the Knoll evaporator which is similar to WL-108, separator have been prepared. This vessel shall be provided with a sampler, a level indicator-controller, and a conductivity recorder alarm. The separator shall vent to the off-gas header. The purpose of the separator is to separate non-condensibles from the condensate as well as to serve as a small monitoring tank to detect any radioactivity that might be entrained. The separator shall drain to the service waste system or to the condensate receivers (WL-106 & 107).

Calculations

(a) Evaporator Calculation

1. Design Capacity = 300 gallons per hour

= 2500 lbs. per hour

Assume 10% reflux = 30 gallons per hour

= 250 lbs. per hour

Total vapor load = 330 gallons per hour

= 2750 lbs. per hour

Volume Reduction to be 30 to 1

Evaporator to be capable of operating at atmospheric pressure or at 100 mm. Hg absolute pressure (26" Hg)

2. Sensible Heat Requirement - assume feed temp. = 55° F
   - assume cell temp. = 80° F

   A. Atmospheric Pressure:

   (1) Sensible heat to preheat feed:

   q = 2750 (212-55) = 432,000 BTU/hr.

   (2) Sensible heat to balance radiation loss:

   $q = (h_r + h_c)A\Delta t$; $h_r + h_c = 1.25$ (Nicholson's Evap. Report)

   = 1.25 x 1000 x (212-80) = 165,000 BTU/hr.

   (3) Total Sensible Heat = 597,000 BTU/hr.

   B. Vacuum (100 mm Hg absolute pressure = 26" Hg vac.)

   Actual press. in pot or collandria = 270 m Hg abs., which corresponds to a B.P. = 165° F.

   (1) Sensible heat to preheat feed:

   q = 2750 (165-55) = 303,000 BTU/hr.

   (2) Sensible heat to balance radiation loss:

   q = 1.25 x 1000 x (165-80) = 106,000 BTU/hr.

   (3) Total Sensible heat = 409,000 BTU/hr.

3. Latent Heat Requirement

   A. Atmospheric Pressure

   q = 2750 x 970 = 2,665,000 BTU/hr.

   B. Vacuum (100 mm Hg abs. press.)

   q = 2750 x 1022 = 2,815,000 BTU/hr.

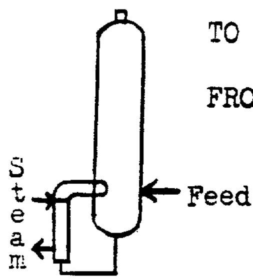
4. Total Heat Requirement

A. Atmospheric pressure; q = 3,262,000 BTU/hr.

B. Vacuum (100 mm Hg abs. press.); q = 3,224,000 BTU/hr.

5. Heating Area Requirement - Collandria or vertical Thermosyphon Reboiler

NOTE: TO PREVENT SALTING OF TUBES, IT IS IMPORTANT TO LIMIT ΔT ON BOILING TRANSFER TO 60° F:



FROM BLAW-KNOX DATA: $h_f = 235$

$h_{fs} = 1000$

$$U = \frac{235,000}{1235} = 190$$

A. Atmospheric Pressure

$$q = UA\Delta T; \; A = \frac{q}{U\Delta T} = \frac{3,262,000}{190 \times 60} = \underline{\underline{287 \text{ ft.}^2}}$$

Assume 3/4" O.D. tubes 8' long;

$$\frac{287}{8 \times 0.1963 \text{ ft.}^2/\text{ft.}} = 183 \text{ tubes}$$

FROM BLAW-KNOX TUBE LAYOUT STANDARDS A 16"ϕ EXCHANGER HAS 216 TUBES 3/4" O.D. on 15/16" Δ PITCH AS THE NEAREST FOR THIS REQUIREMENT.

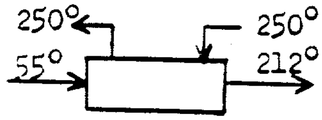
Backchecking to see if U required for this exchanger meets the U = 190 assumed as the basis for the calc.:

$$A = 216 \times 0.1963 = 340 \text{ ft.}^2$$

$$U = \frac{3,262,000}{340 \times 60} = \underline{\underline{160}}$$

This exchanger should be satisfactory if the surface required for sensible heat is adequate.

Surface for Sensible Heat: $q = 597{,}000$ BTU/hr.



$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}} = \frac{157}{1.64} = \underline{\underline{96.5^\circ F.}}$$

$\Delta T_1 = 195^\circ$ $\Delta T_2 = 38^\circ$

FROM BLAW-KNOX DATA: $h_f = 80$ (for mass velocity 2500#/hr. x 10 to recirculation)

$$h_{fs} = 1000$$

$$U = \frac{80{,}000}{1080} = \underline{\underline{74}}$$

$$\text{Surface for Sens. Ht.} = A = \frac{597{,}000}{74 \times 96.5} = \underline{\underline{83.8 \text{ ft.}^2}}$$

Surface Available = Exchanger Area - Area calculated for U = 190:

$$= 340 \text{ ft.}^2 - 287 \text{ ft.}^2 = \underline{\underline{53 \text{ ft.}^2}}$$

This exchanger does not provide adequate surface for Sensible Heat transfer. If the Sensible Heat for feed preheating and balancing radiation loss can be supplied by raw steam sparging in the separator column, this exchanger will be satisfactory.

B. Vacuum (100 mm Hg abs. press.)

Vacuum in collandria should be about 270 mm Hg abs. press. (from calc. by H. A. Ohlgren). This corresponds to B. P. = 165° F.

$$U = 190$$

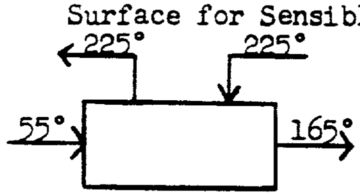
$$\Delta T = 60^\circ \text{ F.}$$

$$q = 3{,}224{,}000 \text{ BTU/hr.}$$

$$\text{Req'd. Area} = A = \frac{3,224,000}{190 \times 60} = \underline{\underline{283 \text{ ft.}^2}}$$

The 16"ϕ shell containing 216 - 3/4" O.D. tubes offers 340 ft.^{2} and is therefore adequate for boiling under vacuum.

Surface for Sensible Heat: q = 409,000 BTU/hr.



$$\text{LMTD} = \frac{110}{\ln \frac{170}{60}} = \frac{110}{1.045} = \underline{\underline{105^\circ \text{ F.}}}$$

ΔT_1=170°F. ΔT_2=60°F. U = 74 (from Blaw-Knox)

$$\text{Surface Area req'd.} = A = \frac{409,000}{74 \times 105} = \underline{\underline{52.5 \text{ ft.}^2}}$$

$$\text{Surface available} = 340 - 283 = \underline{\underline{57 \text{ ft.}^2}}$$

This exchanger is barely adequate for Sensible Heat transfer, but there is too small a margin for fouling. If the sensible heat load is removed by preheating the feed by a raw steam sparger in the separator pot, this exchanger would be satisfactory.

6. Vapor Velocity

A. Atmospheric Pressure

specific volume of water vapor @ 212° F. = 26.8 ft.^{3}/lb.

2750 lb/hr. x 26.8 ft.^{3}/lb. = 73,700 ft.^{3}/hr.

= 1230 ft.^{3}/min.

= 20.5 ft.^{3}/sec.

B. Vacuum (approx. 270 mm Hg abs. at collandria or pot)

specific volume of water vapor @ 165° F. = 69.3 ft.^{3}/lb.

$2750 \times 69.3 = 190{,}000$ ft.^{3}/hr.

$= 3175$ ft.^{3}/min.

$= 52.9$ ft.^{3}/sec.

7. <u>Vapor Velocity through the 216 tube - 3/4" O.D. exchanger</u>

A. Atmospheric Pressure

Internal area per tube $= \frac{.302}{144}$ ft.^{2} $= 0.0021$ ft.^{2}

Internal area for exchanger $= 216 \times .00186 = 0.402$ ft.^{2}

.733 ft.^{2}
for 20"Φ
349 tubes

Vapor Velocity thru exchanger $= \dfrac{20.5 \text{ ft.}^3/\text{sec.}}{0.402 \text{ ft.}^2}$

$= \underline{\underline{51.0 \text{ ft./sec.}}}$

Assume 30% vaporization per pass thru exchanger:

$.3 \times 51.0 = 15.3$ ft./sec.

$.3 \times 20.5 = 6.15$ ft.^{3}/sec.

Then liquid velocity would be $\frac{2750}{3} = 9150$ lb./hr.

Assume specific gravity = 1.2:

$\frac{9150}{62 \times 1.2} = 132$ ft.^{3}/hr.

$= 2.2$ ft.^{3}/min.

$= 0.0366$ ft.^{3}/sec.

Liquid velocity thru exchanger:

$\dfrac{0.0366 \text{ ft.}^3/\text{sec.}}{0.402 \text{ ft.}^2} = \underline{0.091 \text{ ft./sec.}}$

This is viscous flow and the heat transfer coefficient would be too low. Therefore, a higher recirculation rate would have to occur because less vaporization would occur. (Ohlgren says the vapor velocity of 15.3 ft./sec. would sweep the liquid thru at a faster rate by means of bubbles formed in the low part of the tubes.

Zahnstecher questioned the BLAW-KNOX values of

$h_f = 235$ and $U = 190$;

$\therefore$ assume $U = 100$:

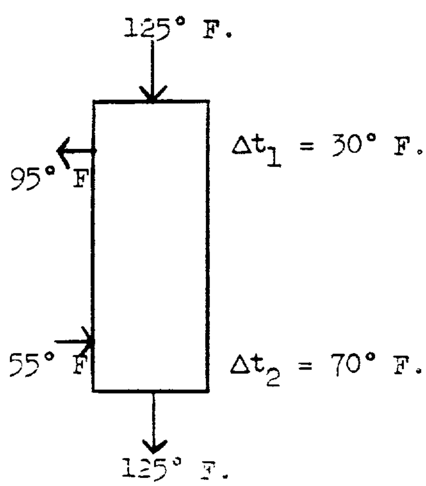
$$A = \frac{3,262,000}{100 \times 60} = \underline{\underline{550 \text{ ft.}^2}}$$

still assume 3/4" O.D. tubes 8' long;

$$\frac{550}{8 \times 0.1963 \text{ ft.}^2/\text{ft.}} = 350 \text{ tubes.}$$

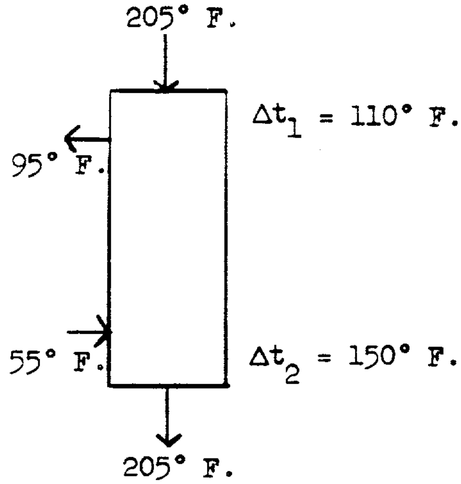
FROM BLAW-KNOX TUBE LAYOUT STANDARDS, A 20" ϕ EXCHANGER HAS 349 - 3/4" O. D. TUBES ON 15/16" Δ PITCH, WHICH IS THE EXCHANGER CHOSEN FOR WL-300.

(b) Waste Evaporator Condenser (WL-301)



$$\text{LMTD} = \frac{70-30}{\ln \frac{70}{30}} = \frac{40}{0.845} = \underline{\underline{47.4° \text{ F.}}}$$

for Vacuum Evaporation



$$\text{LMTD} = \frac{150-110}{\ln \frac{150}{110}} = \frac{40}{0.304} = \underline{\underline{130^\circ\ \text{F.}}}$$

for Atmospheric Evaporation

Duty: To condense 2500 #/hr. water vapor

$= 2500 \times 1025 = \underline{\underline{2{,}565{,}000\ \text{BTU/hr.}}}$ for Vacuum Evaporation

$= 2500 \times 970 = \underline{\underline{2{,}412{,}000\ \text{BTU/hr.}}}$ for Atmospheric Evaporation

Area: 614 tubes 3/4" O.D. x 6' long, 16 BWG

$614 \times 6 \times 0.1963 = \underline{\underline{724\ \text{ft.}^2}}$

Required $U = \frac{q}{\Delta TA}$

$$= \frac{2{,}565{,}000}{47.4 \times 724} = \underline{\underline{75.0\ \text{BTU/hr./ft.}^2/^\circ\text{F.}}}$$

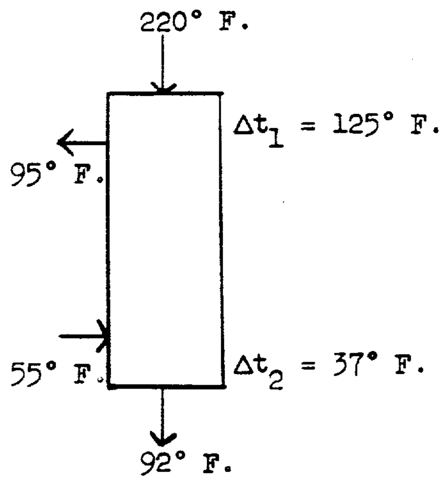
Cooling Water Requirement:

Water Temp. Rise = 40° F. (95° F. - 55° F.)

$$= \frac{2{,}565{,}000}{1 \times 40} = \underline{\underline{64{,}125\ \#/\text{hr.}}}$$

$$= \underline{\underline{128.5\ \text{gal./min.}}}$$

(c) Ejector Exhaust Condenser



$$\text{LMTD} = \frac{125-37}{\ln \frac{125}{37}} = \frac{88}{1.22} = \underline{\underline{72.4^\circ \text{ F.}}}$$

From Knoll Evaporator Flowsheet:

Duty: To condense 462 #/hr. steam and to subcool 128° F. (Estimate 220° F. - 92° F.)

= 462 x 971 (= 449,000 BTU/hr.) +

462 x 128 (= 59,000 BTU/hr.)

= <u>508,000 BTU/hr.</u>

Area: 55 tubes, 3/4" O.D. x 8' long, 16 BWG

= 55 x 8 x 0.1963 = $\underline{\underline{86.4 \text{ ft.}^2}}$

Required U : $U = \frac{q}{\Delta TA}$

$$= \frac{508{,}000}{72.4 \times 86.4}$$

$$= \underline{\underline{81.4 \text{ BTU/hr./ft.}^2/^\circ\text{F.}}}$$

Cooling Water Requirement:

Water Temp. Rise = 40° F. (95° F. - 55° F.)

$$\frac{508{,}000}{1 \times 40} = 12{,}700 \text{ \#/hr.} = \underline{\underline{25.4 \text{ gal./min.}}}$$

ITEM NAME Waste Evaporator Condenser
ITEM NO. WL-301
DRAWING NO. EWV-94A
ITEM LOCATION Waste Evaporator Bldg.
SPECIFICATION BY [illegible]
PURCHASE NO.
DATE & REVISION 12-22-50
PURCHASE ORDER NO.
VENDOR
FUNCTION See Dwg. 5M2-21-P360

DUPLICATE ITEM NOS. None

1. TYPE Shell & Tube
2. SURFACE 724 ft.^{2}

	SHELL	TUBE
3. FLUID CIRCULATED	Water	Water
4. TOTAL FLUID ENTERING	64 200 #/hr.	2500 #/hr.
VAPOR		2500 #/hr.
LIQUID	64,200 #/hr.	
FLUID VAPORIZED OR COND.		2500 #/hr. (Cond)
NON-CONDENSABLE		(Allow for Air Leak)
5. LIQUID-DENSITY & VISCOSITY	1.0	
6. SPECIFIC HEAT-LIQUIDS	1.0 BTU/#/°F	BTU/#/°F
LATENT HEAT-VAPORS	BTU/#	1025 BTU/#
7. TEMPERATURE-IN	55°F. °F	ATM 205 VAC 125 °F
OUT	95°F. °F.	ATM 205 VAC 125 °F
8. OPERATING PRESSURE	85 PSI	12.2 PSI (ATM) or 80 mm Hg Abs.
9. VELOCITY	FT./SEC.	FT./SEC.
10. PRESSURE DROP	Up to 20 PSI	20 mm Hg Abs.
11. PRESSURE DESIGN	120 PSI	25 PSI or Full Vac. PSI
TEST	180 PSI	38 PSI
12. TEMPERATURE DESIGN	°F	°F

13. HEAT EXCHANGED 2,565,000 BTU/HR(VAC.) 47.4 °F. MTD
TRANSFER RATE 75.0 BTU/hr/ft^2/°F SERVICE CLEAN
14. MATERIALS OF CONSTRUCTION:
TUBES: NO. 614 O.D. 3/4" BWG 16 LENGTH 8'0¼" PITCH 15/16"△
SHELL: I.D. 26" THICKNESS 3/8"
TUBE SHEETS, FLOATING THICKNESS
STATIONARY 2 THICKNESS Top 1¼" Bottom 3/4"
BAFFLES 10 TYPE Segmental THICKNESS ¼"
GASKETS

ITEM NAME Waste Evaporator Reboiler ITEM NO. WL-300
DRAWING NO. FMV-93A
ITEM LOCATION Waste Evaporator Bldg. Cell
SPECIFICATION BY F.N.B. PURCHASE NO.
DATE & REVISION 12-21-50 A PURCHASE ORDER NO.
VENDOR
FUNCTION See Dwg. 542-21-P359

DUPLICATE ITEM NOS. None

1. TYPE Recirculating Thermosyphon
2. SURFACE 548 ft.^{2}

	SHELL	TUBE
3. FLUID CIRCULATED	Steam	Salt Solution
4. TOTAL FLUID ENTERING	3500 #/hr.	Depends on Re-circ. Rate to be Calc. by NY
VAPOR	3500 #/hr.	
LIQUID		2600 #/hr. feed 250 #/hr. reflux
FLUID VAPORIZED OR COND.	3500 #/hr. (Cond.)	2500 #/hr. (Vaporized)
NON-CONDENSABLE		
5. LIQUID-DENSITY & VISCOSITY		1.29 (At end of Run)
6. SPECIFIC HEAT-LIQUIDS	BTU/#/°F	1 BTU/#/°F
LATENT HEAT-VAPORS	930 BTU/#	970 BTU/#
7. TEMPERATURE-IN	270 °F	Feed Temp. 55 °F
OUT	270 °F	B.P. 205 °F
8. OPERATING PRESSURE	30 PSIG (42.2 PSIA) PSI	12.2 PSIA (ATM)
9. VELOCITY	FT/SEC.	Depends on Re-circ. Rate FT/SEC
10. PRESSURE DROP	Negligible PSI	5 Max. PSI
11. PRESSURE DESIGN	150 PSI	25 PSI or Full Vac.
TEST	225 PSI	38 PSI
12. TEMPERATURE DESIGN	350 °F	250 °F

13. HEAT EXCHANGED 3,262,000 BTU/HR 60 °F MTD
TRANSFER RATE 100 BTU/hr/ft.^{2}/°F SERVICE CLEAN
14. MATERIALS OF CONSTRUCTION: Type 347 S.S.
TUBES: NO. 349 O.D. 3/4" BWG 16 LENGTH 8'0¼" PITCH 15/16" △
SHELL: I.D. 20" THICKNESS 3/8"
TUBE SHEETS, FLOATING THICKNESS
STATIONARY 2 THICKNESS 1¼"
BAFFLES None TYPE THICKNESS
GASKETS

[redacted]

Feed Tank WL 109

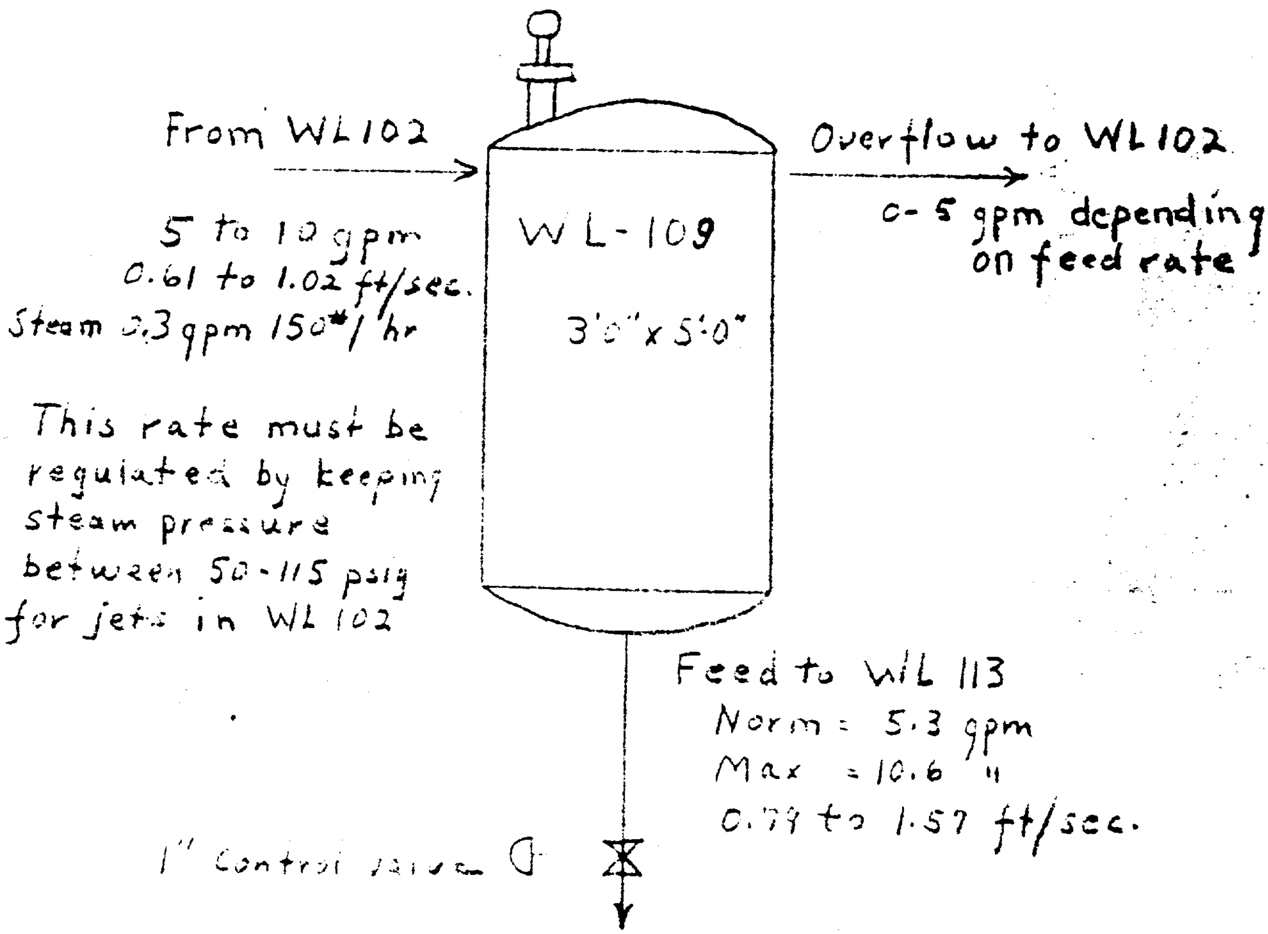


Fig. * 1

[redacted]

[redacted]

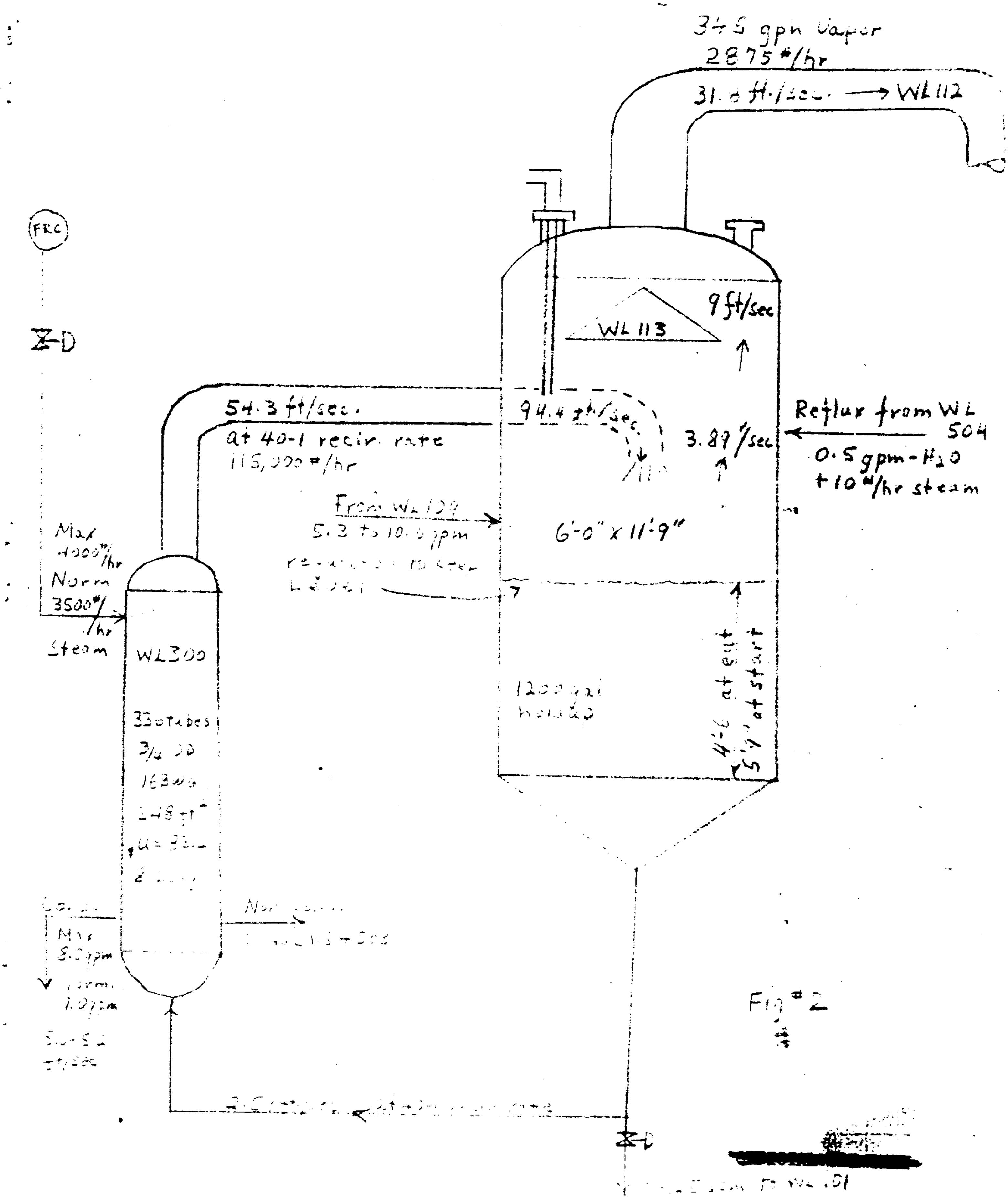


Fig # 2

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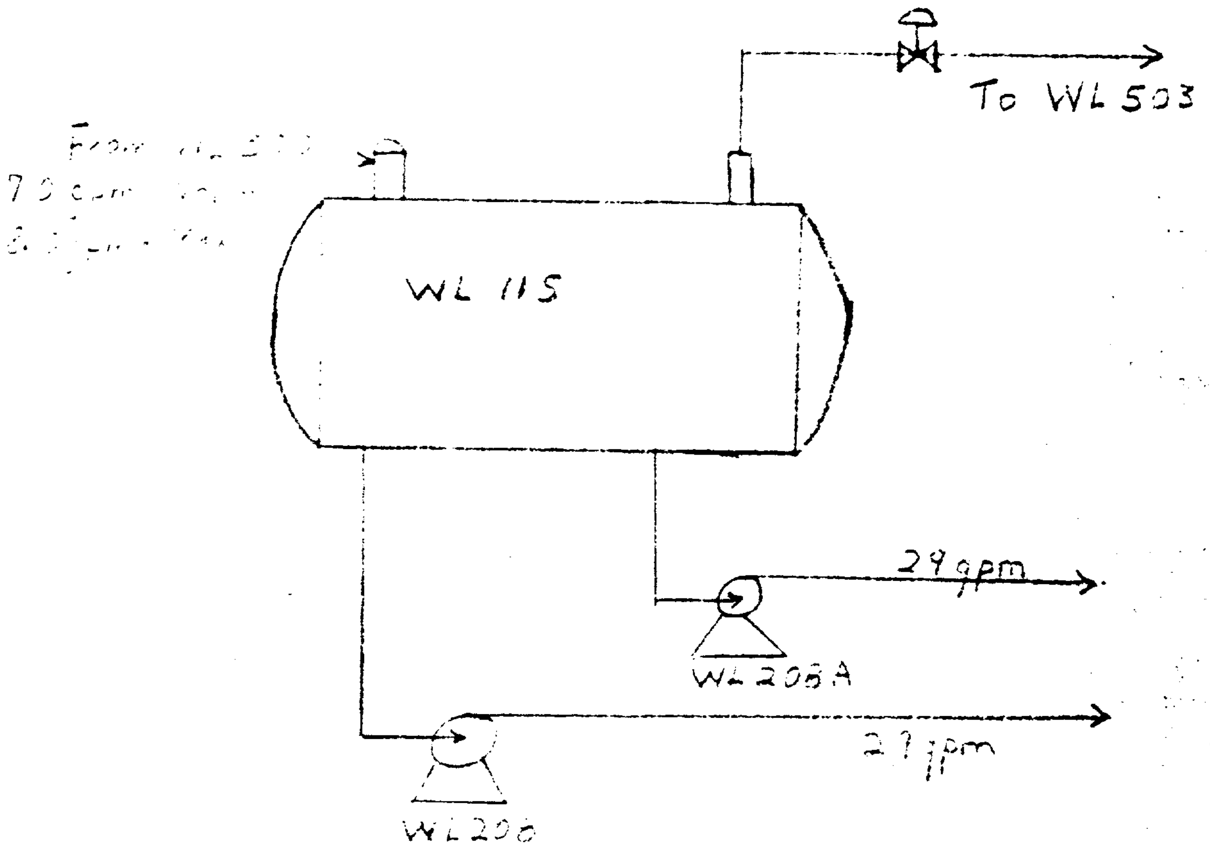
Condensate Tank & Pumps



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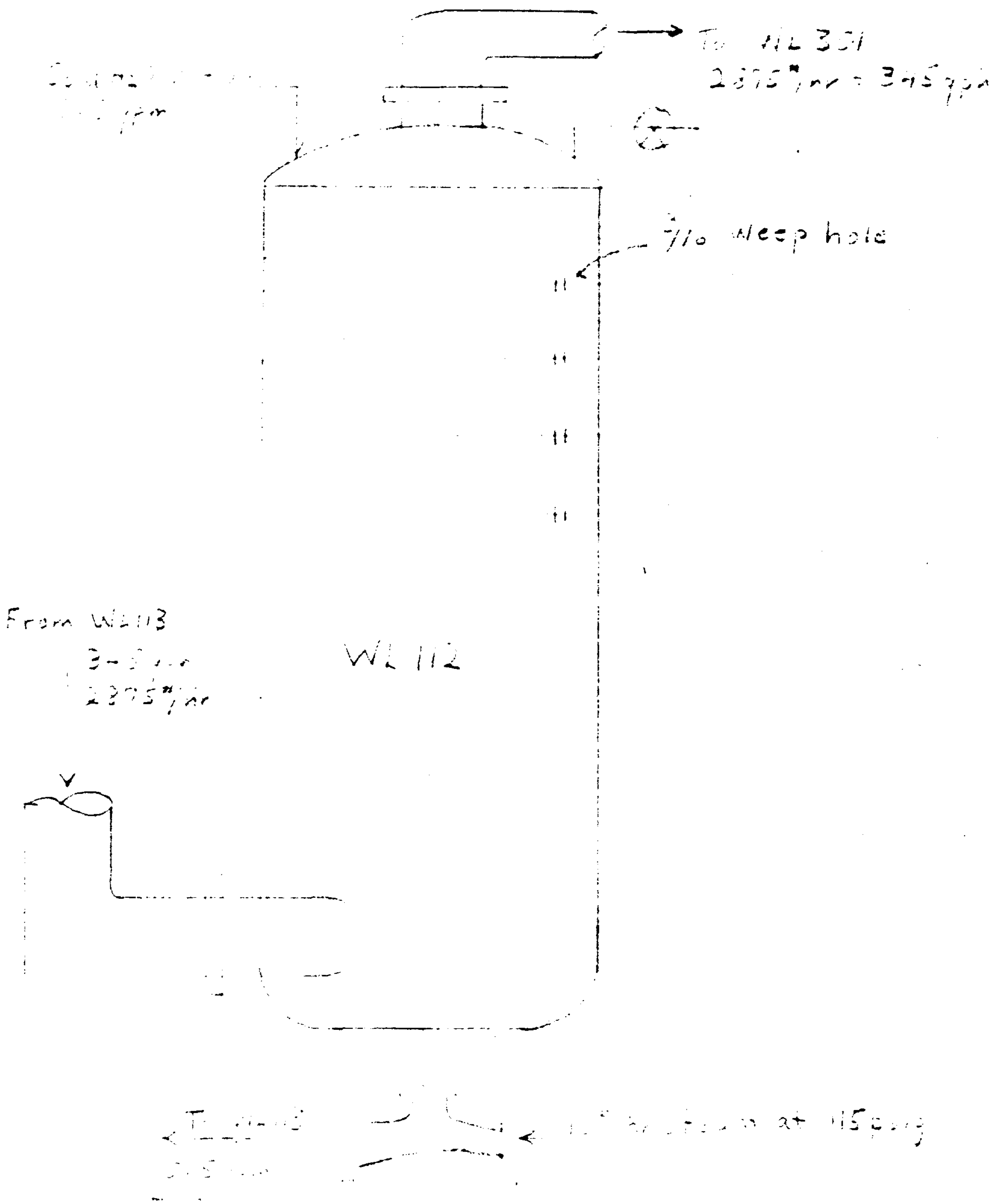

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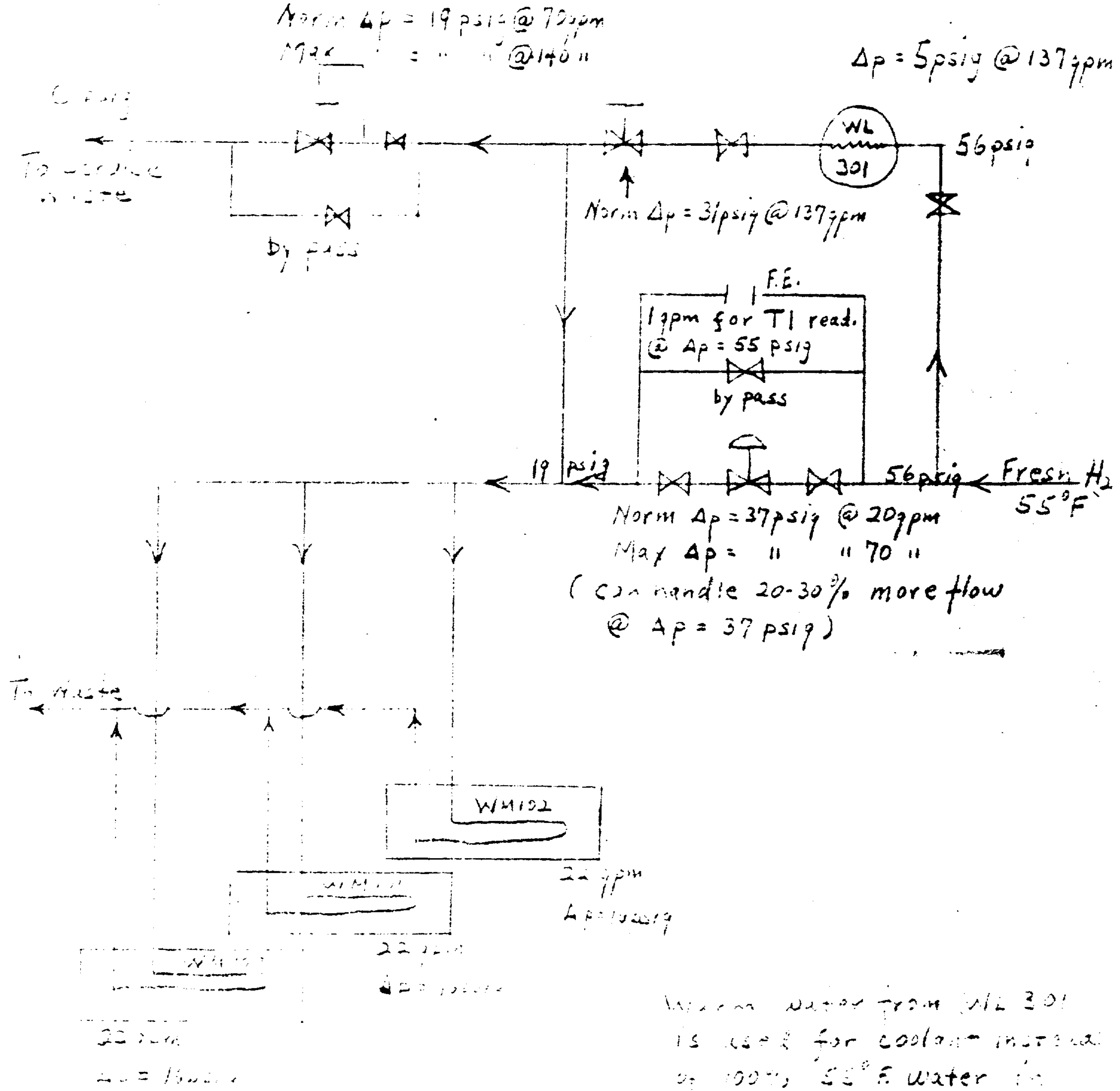
Tempered Water System



Warm water from WL 301 is used for coolant instead of 100% 55°F water in order to prevent viscous film from forming on outside of tank coils.

Fig 5

[redacted]

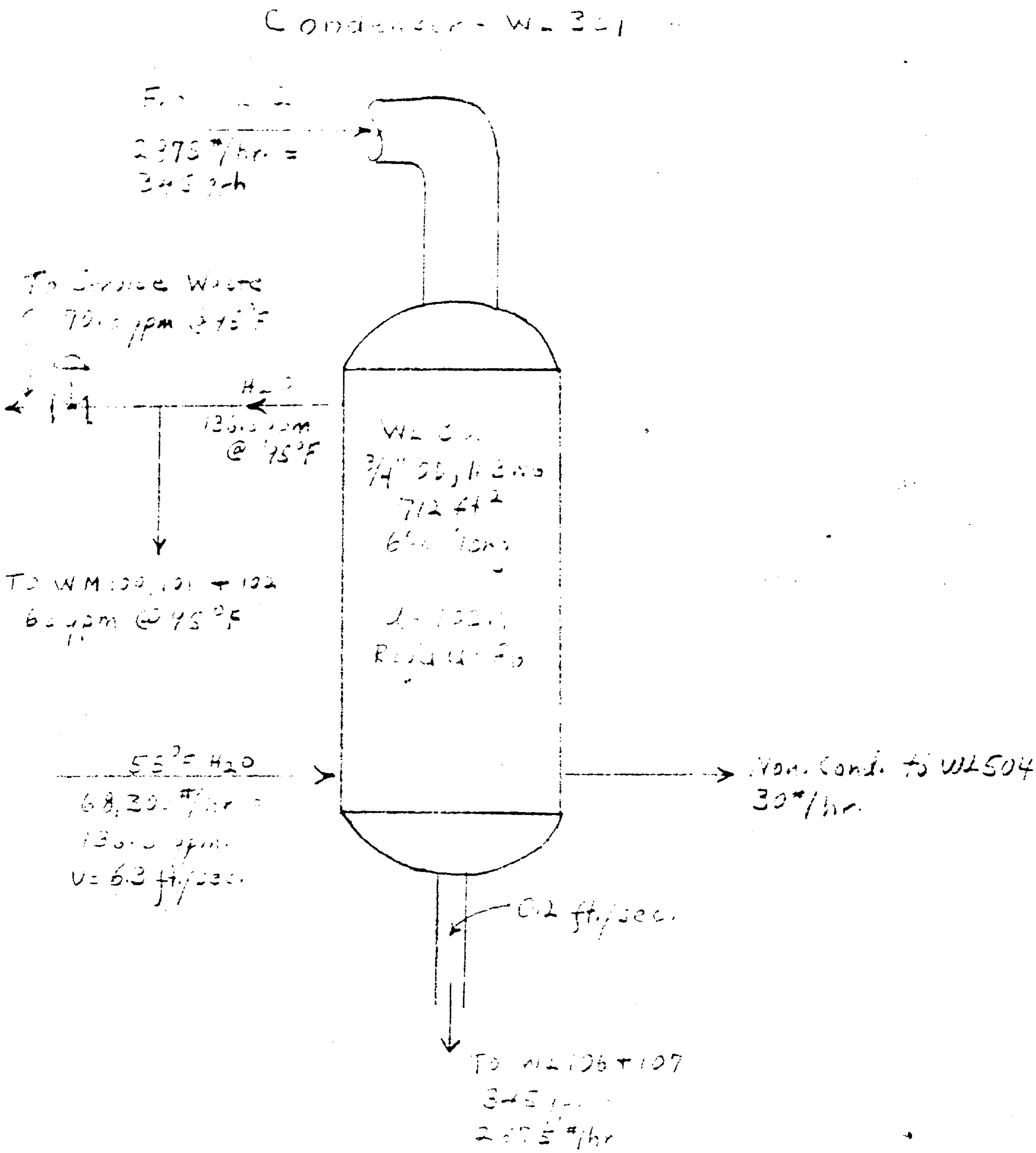


Fig. # 6

Condensate Recievers WL 106 + 107

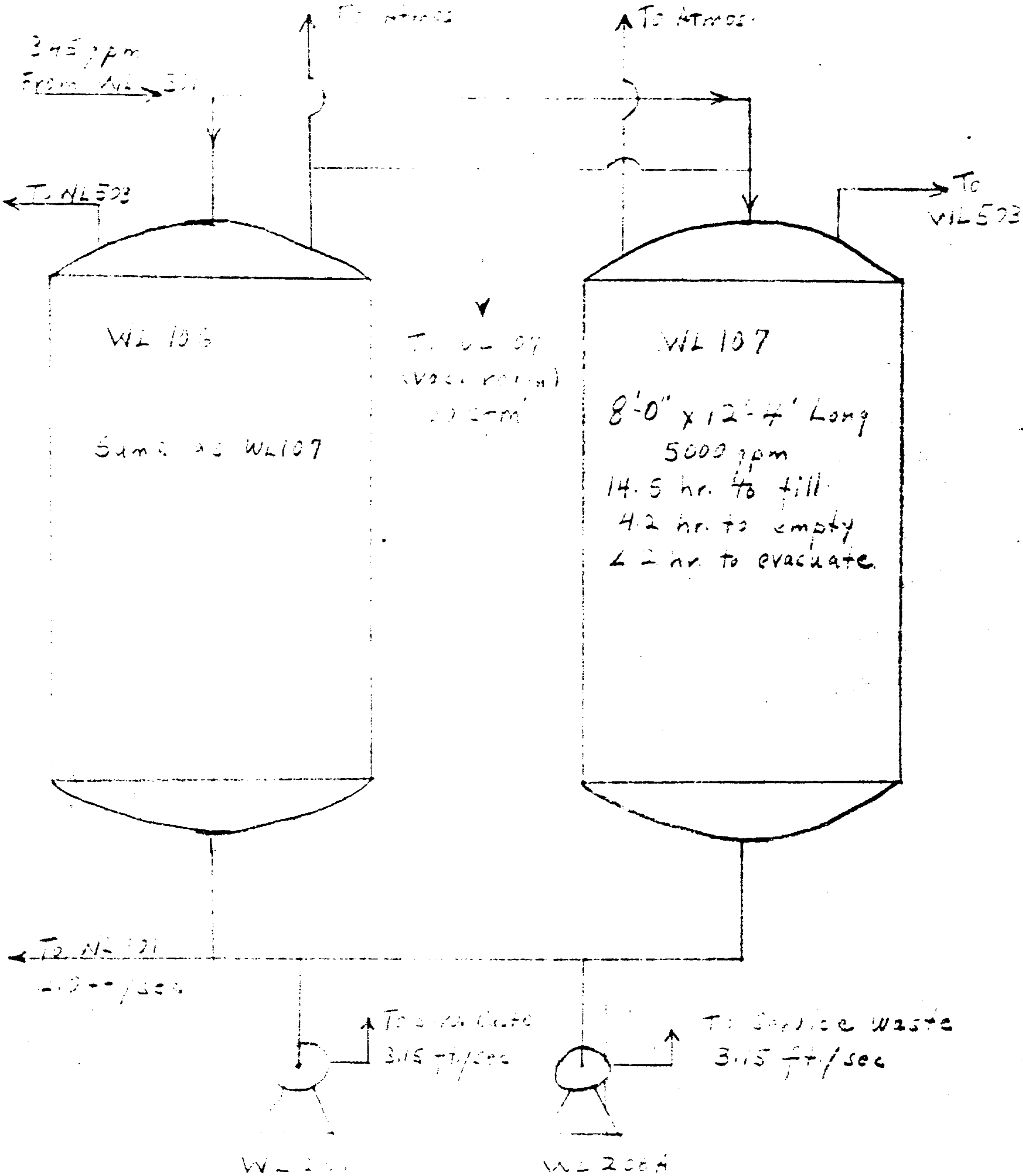
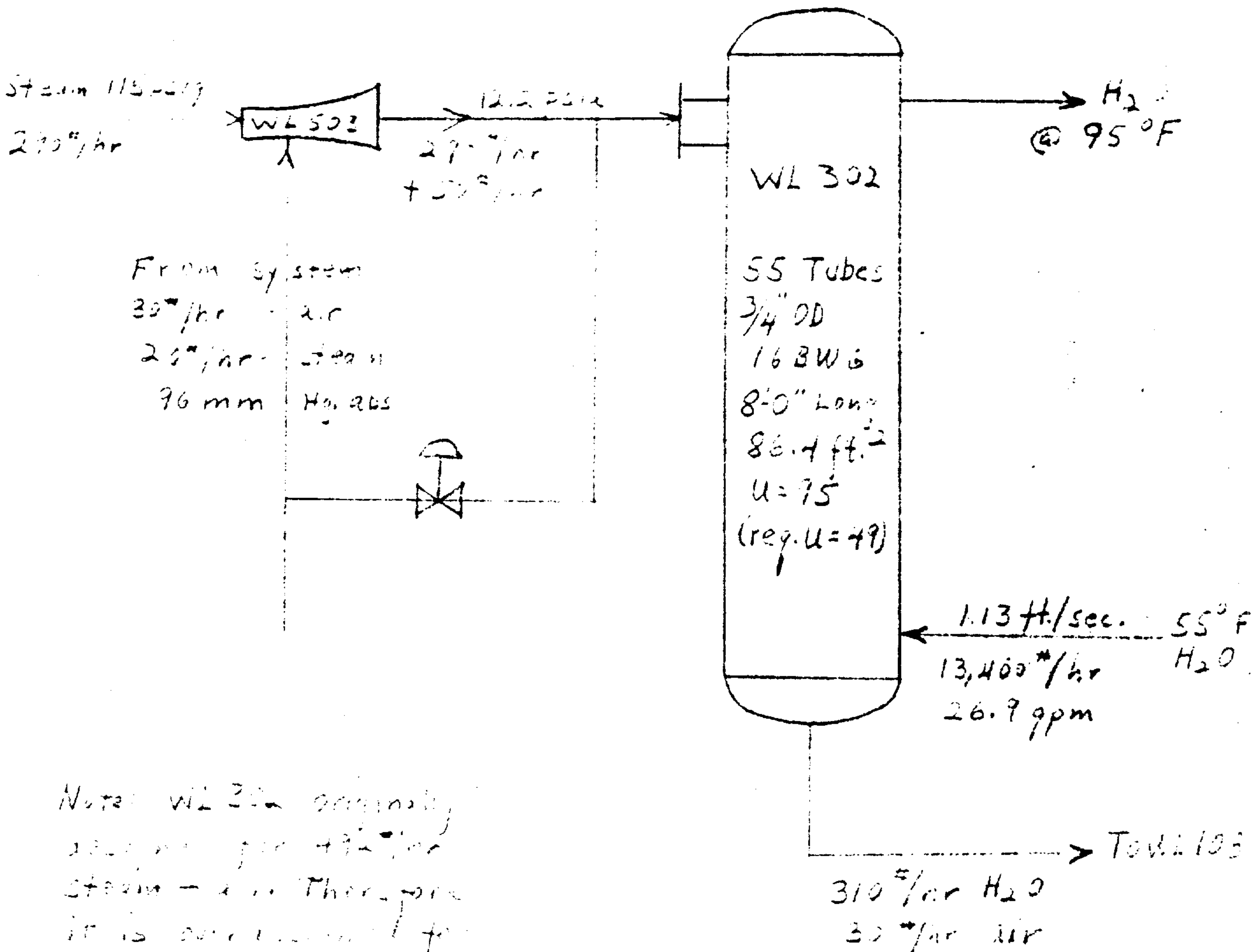


Fig. #7

[redacted] Condenser WL 503 + WL 302



Note: WL 302 originally designed for 492#/hr steam - air. Therefore it is over designed for present 340#/hr load.

Fig.

[redacted]

[redacted]

Jet Condens[redacted]eparator WL 108

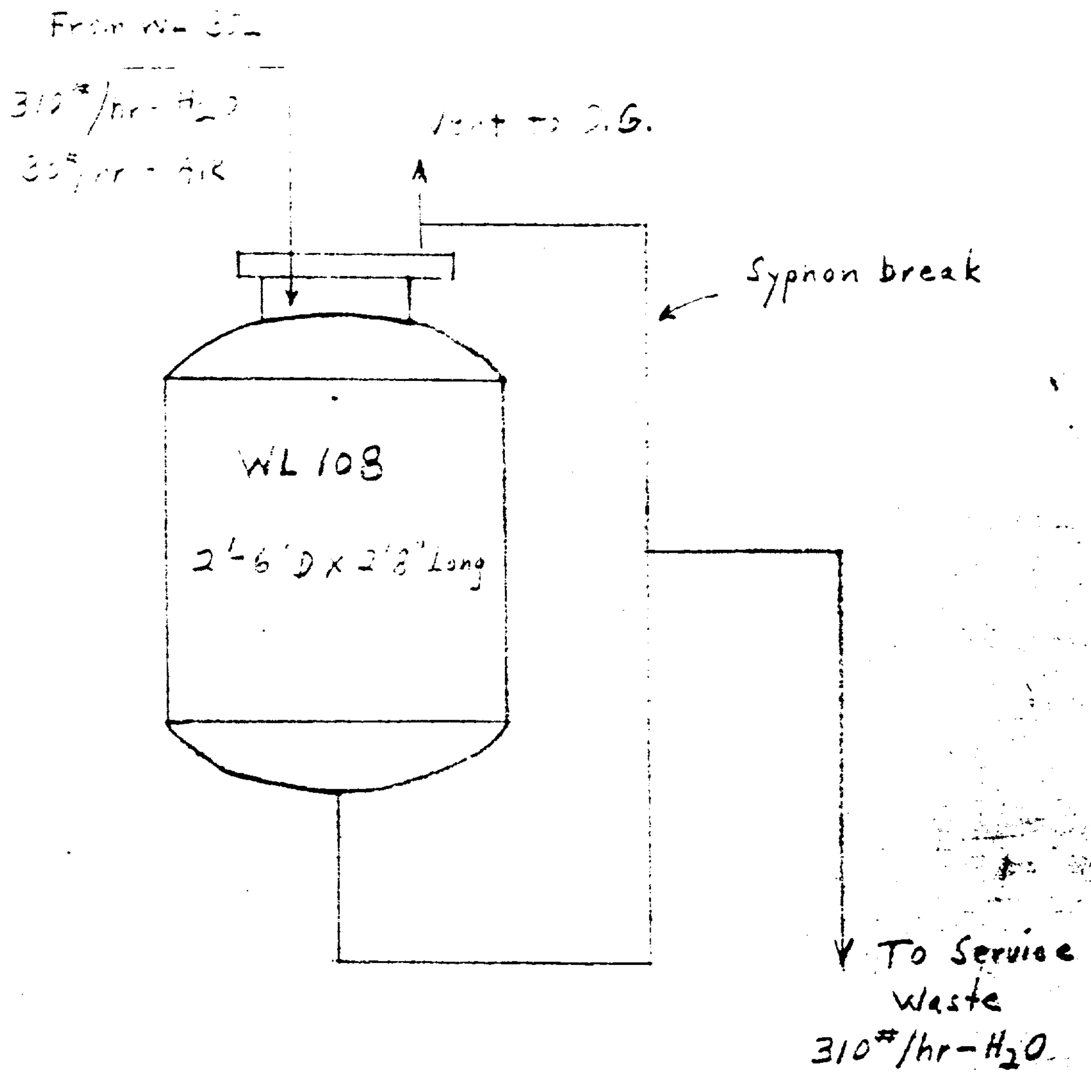


Fig. # 9

[redacted]